The need for, and state of, energy-efficient homes in the United States

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DECLARATION

I, the undersigned, hereby declare that the work contained in this assignment is my own original work and that I have not previously in the entirety or in part submitted it at any university for a degree.

Signature  Date: 23 October 2006

ABSTRACT

Although there are serious hurdles to overcome before green, energy-efficient homes become common; the technological and market-based foundations are already in place to support a shift in standard practice. Many organizations, from the federal government to local non-profits, are driving the transition to more efficient homebuilding practices through research, market-based competition, and tax incentives. However, many builders are resisting the transition, due to the fragmented nature of the building industry and a perceived lack of consumer demand. Because of the nature of the US economy, until American consumers understand green homes and demand builders to build them, green homebuilding will not reach its full potential. If building practices are left unchanged, inefficient homes will continue to cause dire consequences to the world because of their contribution to global climate change.

OPSOMMING

Hoewel daar ernstige struikelblokke bestaan, wat oorkom moet word alvorens groen, energie-doelmatige wonings algemeen raak, is die tegnologiese en markgerigte grondslae reeds gelê om 'n verskuiwing in standaard-praktyk te onderskraag. Verskeie instansies – van die federale regering tot nie-winsgewende organisasies – verleen stukrag deur middel van navorsing, markgerigte mededinging en belasting-aansporings aan die oorgang na meer doelmatige gebruike rondom praktyke ten opsigte van die konstruksie van huise. Weens die gefragmenteerde aard van die boubedryf en die waarneembare gebrek aan verbruikersaanvraag staan talle bouers egter die vermelde oorgang teen. Weens die aard van die VSA se ekonomie en totdat Amerikaanse verbruikers groen tuistes kan verkoop en by bouers aandring om hulle op te rig, sal groen woningkonstruksie nie sy volle potensiaal bereik nie. Indien boupraktyke onveranderd gelaat word, sal ondoelmatige wonings as gevolg van hulle bydrae tot globale klimaatsverandering steeds aaklige gevolge vir die wêreld tot gevolg hê.

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"We should feel a great sense of urgency because [climate change] is the most dangerous crisis we have ever faced, by far. But it also provides us with opportunities to do a lot of things we ought to be doing for other reasons anyway. And to solve this crisis we can develop a shared sense of moral purpose." –Al Gore

INTRODUCTION:

Americans' energy-intensive lifestyles are pumping enormous amounts of greenhouse gasses into the air, directly contributing to climate change. Climate change is altering weather patterns and making local conditions more extreme, which impacts everyone by increasing the intensity and frequency of extreme weather events including hurricanes, droughts, and floods (Valverde, Jr. and Andrews, 2006).

Most experts agree that the global South, and in particular Africa south of the equator, will suffer a disproportionate amount of the hardships from climate change. (University of York, 2005; Desanker, 2002; Fields, 2005). A recent white paper by the United Kingdom's Secretary of State for International Development concludes that global warming will cancel out Western aid and devastate Africa (Benn, 2006). "Climate change could undo even the little progress most African countries have achieved so far in terms of development," says Anthony Nyong, a professor of environmental science at the University of Jos in Nigeria (Fields, 2005).

As temperatures warm in Southern Africa, arable land will diminish. Because they are poor, sub-Saharan African countries will likely have a tougher time coping with climate change's impact than rich countries (Fields, 2005). This is especially tragic because sub-Saharan nations emit very few green house gases compared to most of the rest of the world. All of Africa, which contains 10% of the world's people, produces only 3.6% of the global CO_2 emissions. It is the lowest emitter of any inhabited continent (other than Australia, which has only a fraction of Africa's population). The U.S. on the other hand has only 4.6% of the world's population but emits 23.8% of the world's carbon dioxide (CO_2) emissions (Energy Information Administration, 2006). Because of the disproportionate amount of greenhouse gases produced by the United States and the worldwide ramifications that climate change will cause, the U.S. has an ethical obligation to reduce its greenhouse gas emissions.

But the U.S. continues to increase its energy use, emitting 2% more greenhouse gases in 2004 than 2003 (Energy Information Administration, 2006). Because very few Americans are willing to sacrifice their lifestyles, the only practical way that the U.S. can substantially reduce greenhouse gas emissions is to start using energy more efficiently. However, curbing energy and resource use in the U.S. is a daunting task. Americans have formed a society based on artificially low electricity, oil, and gas prices and aren't inclined to conserve energy (Buck and Verheyen, 2001). Although there has been a great deal of publicity and worry about the recent increases in energy and gas prices, many experts don't expect any fundamental changes in how American society views energy use until oil rises to over $100 a barrel (Roberts, 2005). For example, U.S. motorists are still not making a fundamental decision to avoid purchasing gas-guzzling SUVs: instead they are opting for only an incremental efficiency gain by purchasing SUVs that get 18 miles per gallon as compared to 14 miles per gallon while vehicles are available that achieve 40 miles per gallon and above (Associated Press, 2006). And despite the recent dramatic rise in gasoline prices, Americans are driving more in 2006 than ever before (Hargreaves, 2006).

One of the most promising ways to curb America's voracious appetite for energy and natural resources is by improving the efficiency of buildings. This approach has promise because of the sheer quantity of energy use that buildings account for, and because it requires little to no day-to-day behavioral change by the average American (it only requires them to substitute their purchase of a conventional home with a green home). Survey after survey shows that most Americans care about the environment, but are not willing to sacrifice their lifestyle or don't know how to make smart environmental decisions, such as taking public transit instead of driving automobiles (American Demographics, 2001; Scott and Willits, 1994; Corbett, 2005). Making buildings green has promise because green buildings can look exactly like the conventional buildings that people are used to seeing. So Americans don't sacrifice anything because they are getting a similarly looking product. In addition, green buildings typically perform better than conventional buildings (are more comfortable, take less maintenance), and have higher customer satisfaction (Advanced Energy, 2006). In contrast, most fuel-efficient cars (hybrids and compact cars) look substantially different from the SUV's and pickups that many Americans drive, and don't have the features that many drivers look for (less cargo room, slower acceleration, lower towing capacity).

Buildings also use more energy than any other sector in the United States. On an annual basis, buildings in the United States consume 39% of America's total energy. That is more than either the transportation sector (28%) or the industry sector

(33%). US buildings use 71% of the country's electricity and 53% of the natural gas, according to the 2005 Buildings Energy Databook, and contribute 9% of the world's CO_2 pollution. The 110 million homes use a majority of all building use in the nation. Housing accounts for 21% of the national energy use (22 quads of energy), representing 5% of the world's CO_2 emissions (US DOE, 2005).

By using more efficient homebuilding methods and materials alone (and not changing any of the energy and resource inefficient designs), "it is estimated that we could reduce the energy, resource consumption and/or waste production by 50-60% without decreasing value, aesthetics or function" (Green Building Pages, 2004). By using eco-friendly design practices, the value, aesthetics and function of a home actually increases while the footprint would further decline (Birkeland, 2004). Americans who live in green homes are also more satisfied with their houses than those who live in conventional homes, implying that they get a better product (Advanced Energy, 2006).

So why aren't green homes the norm? The problem is that most consumers and builders are not familiar with green building. But both groups are beginning to be more exposed to green building. Almost every building and design publication and many news sources have announced (albeit a bit preemptively) that green buildings have hit the mainstream (Arieff, 2006a; Arieff, 2006b; National Association of Home Builders, 2006; Christie, 2006; Adler, 2006; Fedrizzi, 2004; Vanity Fair, 2006; Dooley and Rivera, 2004; Beck, 2006; Fortune Magazine, 2006; Lockwood, 2006). Even the pro-growth anti-regulation National Association of Home Builders has produced their own green building guidelines. A section of their weekly email, Nation's Building News, is dedicated to green building. But to date, green homes make up less than 1% of all housing currently being built although ENERGY STAR homes are approaching close to 10% of all housing starts (ENERGY STAR, 2006).

In addition to the lack of familiarity with green building, builders typically are slow to adopt change. So when they do become familiar with the concepts of green building, there still will be a delay until most builders actually start building green. There are a variety of perceived and real barriers that keeps the homebuilding industry from innovating, including:

- A majority of the nation's homebuilders are small or mid-size companies, producing 68% of the nation's value in homes. Because there is a minimal profit margin and due to the small size of most companies, this sector is quite risk-averse.

- The building industry is diffuse and fragmented, making it difficult for education and adoption to spread.
- There is a perception among homebuilders that buyers have a conservative “tried and true” mentality, inhibiting the diffusion of new technologies.
- Environmentally responsible homes often have a slightly larger up front price. Although this translates to significantly reduced operating and life-cycle costs, lower initial home cost is generally more important to homebuyers than lower life-cycle costs.
- Builders blame lack of homeowner demand for slow adoption, and few trusted manufacturers advocate environmentally conscious building products (Koebel et al., 2003; McGraw Hill Construction, 2006).
- Change takes effort; self-education and education of their workforce. If builders can sell their product without this additional effort, there is little motivation to change.

In order to spread awareness of environmentally conscious building practices, all of these barriers must be addressed. Homebuilder’s perceived risk of trying new technologies must be minimized; better paths for information dissemination on building technologies must be utilized; the perception that building energy-efficient homes is significantly more expensive must be corrected; and most importantly, builders must be convinced that a majority of potential homebuyers strongly desire high-performance, healthy, energy-efficient homes. Green building advocates must educate and persuade both builders and homebuyers that green is the way to go. Numerous governmental and non-governmental organizations are attempting this, although most of their focus is on building science research and educating builders, with little attention being paid to catalyzing consumer demand.

The federal government has been the primary driver of research and development for high-performance building strategies. Many of their findings translate into homes that are more energy-efficient and durable. The federal government is also attempting to catalyze the demand for energy-efficient appliances and building envelopes through tax incentives. A great deal of the existing demand – and technology transfer – is being driven by local green building programs, and increasingly by the leading national green building organization, the U.S. Green Building Council and their program LEED (Leadership in Energy and Environmental Design).

What is green building?

Green building is the most stringent standard in homebuilding. Green buildings are energy-efficient, healthy, resource-efficient, and durable. High-performance building is similar, but the environmental benefits, in particular resource-efficiency, are not addressed. Energy-efficient building prioritizes only energy-efficiency. So, while a green building is energy-efficient, an energy-efficient building is not necessarily green, although energy-efficiency is a major component of green building.

FEDERAL GOVERNMENT INVOLVEMENT:

The federal government has been at the forefront of promoting advanced building technologies and techniques, as well as leading the research, development, and implementation of energy-efficient construction and renovation. Three significant federal departments, the Department of Energy (DOE), the Environmental Protection Agency (EPA), and the Department of Housing and Urban Development (HUD) have recently teamed up to develop an overall strategy to address building energy-efficiency. This new collaboration, Partnerships for Home Energy Efficiency, has four overall strategies for 2006-2007.

Department of Energy:

The Department of Energy, through the Office of Energy Efficiency and Renewable Energy's (EERE) Building Technologies Program, aims to achieve marketable net-zero-energy buildings – buildings that use up to 70 percent less energy than today's International Energy Code, and generate the little energy that is still required through renewable technologies such as photovoltaics. The Building

Technologies Program has a three-pronged strategy: 1) conduct research and development on building components and systems; 2) set energy efficiency codes standards for appliances and building components; and 3) validate technologies in order for them to achieve maximum impact in the marketplace (Polluck, 2006). DOE's flagship program in the homes sector is Building America, which advocates a systems engineering approach to home building and rehabilitation. Building America consists of teams of architects, engineers, builders, equipment manufacturers, material suppliers, community planners, mortgage lenders, and contractor trades. These teams are designed to research and implement whole-house building solutions to improve the energy-efficiency of homes. In addition, DOE implements the National Weatherization Assistance Program to improve the energy efficiency of low-income housing through simple measures like air sealing and adding insulation. In 2004 DOE funded the weatherization of 100,026 homes, and an additional 67,051 were weatherized with non-DOE funding. As of 2005, 2,908,189 homes were weatherized with DOE funds and 5,840,811 total homes were weatherized.

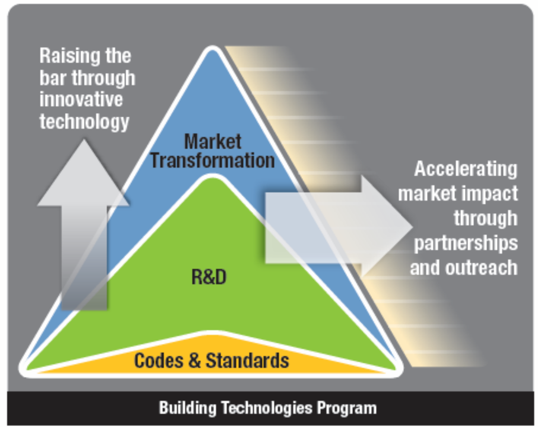

Table 1: Steps as to how the Building Technologies Program is achieving market transformation (Polluck, 2006).

Building America has been a very influential research and develop program. Their research and development is a cornerstone of almost all building science programs today, including every green building program. In 2005 and 2006, Building America released user-friendly best practices guides for each of the six climate regions in the United States. These guides, if properly distributed, should have a significant impact on home building practices.

	Current Home	Energy Star Home	2002 ZEH	2020 ZEH
Size (sq ft)	2200	2200	2200	2500
Typical Cost/ Incremental Cost	$235,000	No Incremental Cost	$75,000 over comparable conventional costs	$20,000 over comparable conventional costs
Kwh/day Consumption	58 kwh/day	49 kwh/day	25 kwh/day	15 kwh/day
Renewables	0	0	50% Solar Hot Water 6 KW of PV	100% Solar Hot Water/Space Heating 3-4 KW of PV
Percentage from Grid	100%	100%	30%	0

Table 2: DOE Building Technologies' Program goal: a cost-effective off the grid zero energy home by 2020.

Environmental Protection Agency:

The Environmental Protection Agency works with DOE to run ENERGY STAR, a voluntary public-private partnership program designed to promote energy efficient lighting, appliances, building envelopes, and more. ENERGY STAR has been very successful at leveraging funds from manufacturers and other partners for advertising and outreach. 64% of U.S. consumers recognize the ENERGY STAR brand, but primarily associate it with appliances and other smaller items (Consortium for Energy Efficiency, 2005). Many speculate that if consumers were familiar with the ENERGY STAR homes program, the demand would be far greater because of the low incremental costs of building an ENERGY STAR home versus the benefits of owning and operating it (Vogel et al., 2006). 131,000 ENERGY STAR qualified homes were built in 2004, and an estimated 200,000 built in 2005 (See Table 3).

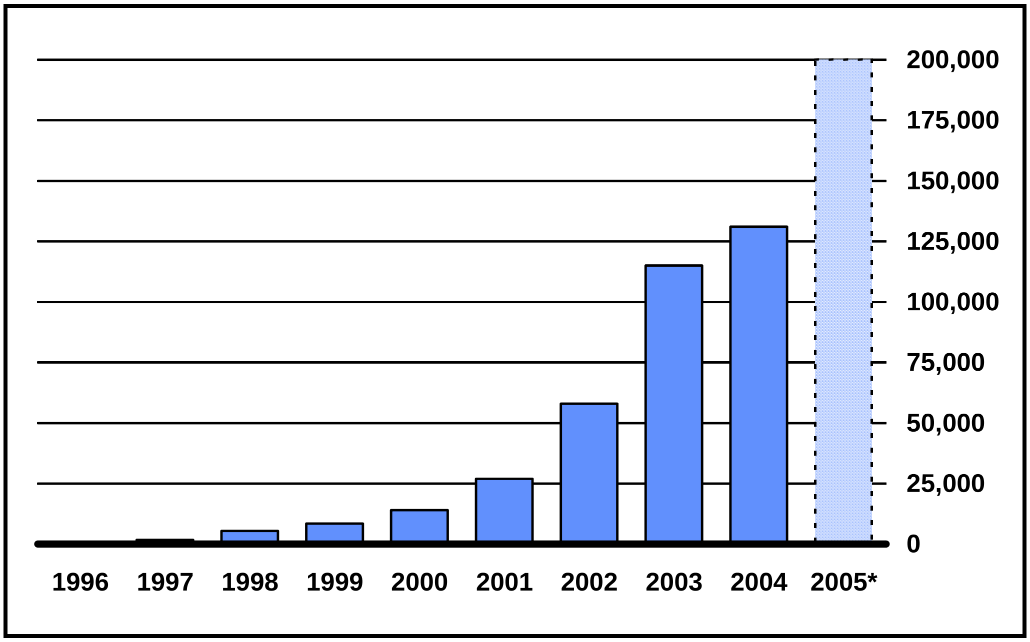

Table 3: Annual number of ENERGY STAR homes built (ENERGY STAR, 2006).

Each ENERGY STAR qualified home is estimated to save 2,040 kWh/yr, and 131 therms/yr. For each home, these improvements would result in over $300 in annual utility bill savings (depending on utility rates), and roughly 3,950 fewer pounds of CO_2 pollution per year (ENERGY STAR, 2006).

Department of Housing and Urban Development:

The Department of Housing and Urban Development’s overall mission is to increase homeownership, support community development, and increase access to affordable housing. Energy costs are becoming an increasingly significant barrier to affordable housing, where utility bills can run as high as 15 percent or more of the disposable income in the lower-income sectors of American society. HUD’s Energy Action Plan includes providing information, technical assistance, and training to HUD customers and partners; promoting Energy Efficient Mortgages for new homebuyers; providing incentives for energy efficiency in competitive grant programs; streamlining energy performance contracting in public housing; encouraging the adoption of ENERGY STAR qualified new homes for new construction or substantially rehabilitated housing; and exploring incentives for energy efficiency in assisted multifamily housing.

In addition to these efforts to address energy efficiency in affordable housing, a HUD administered program, the Partnership for Advancing Technology in Housing

(PATH), strives to make builders comfortable with new technologies and techniques that improve energy efficiency and environmental performance, among other benefits. With much less funding than what DOE and EPA's building programs receive, PATH has played an integral role in pushing specific building products to a more mainstream audience. Builders have sited trade journals as one of the top two most trusted ways of learning about new trends in the industry (McGraw-Hill Construction, 2006). The key is to tailor the articles to the climate and specific energy codes. This, fortunately, is relatively easy since there are so many building science and energy-efficiency experts throughout the country (Residential Energy Services Network, 2006). PATH has written 72 articles for building trade publications since 2002, 20 from January to July 2006 alone (PATH, 2006).

Partnerships for Home Energy Efficiency:

The three aforementioned federal agencies have teamed up to develop an overarching strategy to reduce redundancies while promoting home energy-efficiency. The primary strategy is to promote ENERGY STAR qualified products, which will be promoted primarily by the EPA. DOE and HUD will promote ENERGY STAR within their outreach activities, where relevant. The major challenge for these organizations is that they have similar, yet competing websites, which can be confusing for people looking for information. This is especially confusing when the information someone seeks is split between two websites. PHEE has yet to develop a website which would serve as a clearinghouse for all relevant home energy-efficiency information.

STRATEGY 1: Expand efforts to promote ENERGY STAR products A. National outreach on energy-efficient lighting B. National outreach on heating C. Revised energy-efficiency specifications for ENERGY STAR qualified homes **STRATEGY 2:** Develop new energy-efficiency services to provide homeowners with greater savings A. Expansion of home performance with ENERGY STAR B. Protocols for energy-efficient remodeling of existing homes C. DOE release of HVAC best practices guides for home remodelers D. New certification and accreditation standards and quality assurance criteria for home performance contractors E. New ENERGY STAR guidelines for proper installation and verification of HVAC equipment F. Expansion of home performance with ENERGY STAR to new regions **STRATEGY 3:** Promote energy-efficiency in affordable housing with the HUD phase II energy action plan for affordable single and multi-family homes **STRATEGY 4:** Continue to invest in innovative research building science technologies, practices, and policies A. DOE release of 30 percent best practices guides B. DOE release of energy-efficient remodeler training

Table 4: Partnerships for Home Energy Efficiency strategies for 2006-2007 (D&R International, 2006).

Federal Tax Incentives:

Another way that the federal government is promoting energy-efficient building is by catalyzing demand through tax incentives. The Energy Policy Act of 2005 touches virtually every type of production and end use of energy in the U.S., and provides tax credit to the production of new energy efficient homes and buildings. The stated goal is to reduce the demand on the country’s aging utility infrastructure, and reduce America’s dependence on foreign fuel sources.

The Act rightly emphasizes a building’s energy use, rather than the materials that go into the construction of the building. A recent study by the Consortium for Research on Renewable Industrial Materials shows that the energy required to manufacture, maintain, and demolish a home is only 8 to 11% of the energy the structure will account for over its life (estimated to be 75 years for the study). The remainder is energy used to heat and cool the home. The difference would be even more significant if lighting and appliance use was factored in (Lippke et al., 2004).

The Act provides a $2,000 business credit for homes that have a certified heating and cooling energy use that is 50% less than International Energy Conservation Code (IECC) 2004. There is also a $1,000 credit for Energy Star HUD Code homes with certified heating & cooling energy 30% less than IECC 2004.

There are also tax credits for specific upgrades. Taxpayers make get a rebate of 30% of the installed cost of solar water heaters up to $2,000, and 30% of the installed cost of photovoltaic systems up to $2,000. There is also a $500 deduction for improvements to existing building envelope upgrades equal to 10% of the material cost of windows, doors or insulation. In addition, there are smaller tax credits for replacing existing furnaces, air handlers and hot water heaters with new energy-efficient models.

Energy Codes:

Mandating building codes is the only avenue outside of consumer demand to bring about broad changes to the building industry. The federal government's programs, although important, primarily reach only the 2% to 10% of builders on the cutting edge, while the rest, and majority, of the building community remains unaffected. In the past decade, the federal government has engaged the building community to develop residential building energy codes. These codes substantially reduce the energy used in new homes and gut rehabs by up to and over 50%. Each state has the option of accepting the energy code, or any part within it, into their building codes. In addition, many local jurisdictions can pick and choose which items of the state's energy codes, if any, that they will use.

The first IECC came out in 1998, and subsequent revisions have occurred in 2001, 2003, and 2004. Currently, 35 states have adopted, at least in part, versions of one of the four IECC's. 12 other states are still using early Model Energy Code standards, and four states have no energy codes (Building Codes Assistance Project, 2006).

New revisions are generally more stringent than previous codes, and they also attempt to become more user-friendly. The committee responsible for writing the new IECC usually weighs the cost of implementing a recommendation against the energy savings it provides. The committee receives a great deal of public input, much of it from NAHB, which lobbies to keep the codes from becoming more stringent. Each state has a very different history dealing with energy codes. California, often at the forefront of energy-efficiency initiatives, developed their first statewide energy requirements for low-rise residential buildings in 1975. California now has its own code, Title 24, Part 6, which meets or exceeds 2003 IECC, and is mandatory statewide. It is the most stringent statewide energy code in the country. Louisiana, on the other hand, has never had an energy code for single-family residential construction. In fact, until Hurricane Katrina hit, they never had a statewide single-family residential building code. But the devastation of Katrina brought the need of building codes to the limelight, and Louisiana has since adopted the 2003 IECC statewide amongst other building codes, which will go into effect on January 1, 2007. Although not a perfect comparison because the climates aren’t identical, nonetheless the reduction in energy use is still due in large part to the fact that California had an energy code, while Louisiana did not.

Energy codes are easy to meet:

It is not difficult for builders to meet California’s energy code, which is the most stringent state code in the country. If a builder can achieve California’s code, Title 24, with minimal cost increases to the normal building standards, then any other builder in the nation should be able to meet their local energy codes, and greatly reduce the energy needed to heat, cool, and light a home.

In January 2006, California passed new building energy codes, called Title 24. Title 24 of 2006 improves upon the existing Title 24 standards; in particular it calls for a reduction in peak load demand. To meet Title 24 standards, builders are required to install more efficient lighting, cooling equipment, and often more effective building envelope insulation.

Doug Beaman, energy consultant and coordinator of the California Home Energy Efficiency Rating Services (CHEERS), recommends three easy, cost-effective efficiency upgrades. First, install an air conditioner that is at least 13 SEER. SEER, the Seasonal Energy Efficiency Ratio, is a standard measure to rate the efficiency of central air conditioners; the higher the SEER, the more efficient the system. SEER takes into account that the air conditioner's efficiency changes with different temperature and humidity conditions. Second, add thermostatic expansion valves. A thermostatic expansion valve is used to meter the flow of liquid refrigerant entering the air conditioner’s evaporator at a rate that matches the amount of refrigerant being boiled off in the evaporator. Third, be sure you have tight ducts. Ducts are metal or plastic tubes that transport the conditioned hot or cold air from your furnace or air conditioner to the rooms in your home. Most duct systems aren’t properly sealed, so they leak between 10 and 30 percent of the air.

Energy codes are easy to meet (continued):

If all three measures are used, Beaman foresees significant savings. “Between the TXV, the 11 EER air conditioner, and tight ducts, I have a total reduction in my energy consumption of about 13 percent.”

That 13 percent may vary depending on the climate, since these measures have a larger impact on cooling than heating loads. However, those savings apply to most of the state.

In addition to these measures, Beaman also suggests that builders consider tankless water heaters as a way of reducing energy use—especially in milder climates where the upgrades to the cooling system won’t have as large an impact on total energy savings. Tankless water heaters are about two to four times the cost of conventional tank water heaters, but they save up to 20 percent of water heating energy. They also take up far less space, which can be a significant benefit for smaller homes.

George Nesbitt, a building performance contractor, HERS rater and owner of Environmental Design/Build, believes that these cooling systems measurements are a great way to meet code, but also recommends that builders start by considering energy use at the design stage of their projects.

“The cheapest way to meet code would be to design the building to perform efficiently, using the performance software as a design tool,” said Nesbitt. “If you make the right choices up front, you will far exceed Title 24, and at no extra cost. If you are 15 percent above Title 24 code, you can have your home Energy Star qualified and may be eligible for utility rebates; 50 percent above 2003 International Energy Conservation Code and you get a $2,000 tax credit.”

Nesbitt recommends properly sizing mechanical equipment – specifically the HVAC system. Proper installation requires the HVAC contractor to use the Air Conditioning Contractors of America’s Manual J for sizing rather than rules of thumb, which tend to result in too large of a unit. Correctly sized units are less expensive and more energy efficient, dehumidify better, last longer, and provide better comfort than larger, incorrectly sized equipment.

Most of these measures are relatively inexpensive, but they do require some advanced planning. It is recommended that builders start thinking about energy use early on; the sooner they do, the more cost-effective the measures will be. Last-minute upgrades, as most will agree, can be quite expensive.

“You’ll only run into trouble if meeting code is a tail-end decision of, ‘Oh, yeah, we have to comply with the code,’” said Nesbitt (Foss, 2006).

The incremental cost for installing a 13 SEER air conditioner with a thermostatic expansion valve is less than $50 over normal building standards. The incremental cost for the HVAC contractor to properly airseal a duct system is $100, and it shouldn’t take more than half an hour over the typical installation time.

GREEN BUILDING PROGRAMS:

Many initiatives outside the federal government realm are working towards making the U.S.'s housing stock more efficient. The most significant programs are the 40 plus local, regional and national green building programs that certify buildings as being green. The programs are typically collaborations between local home building associations, local government, and environmental non-profits. Many of them have used the ENERGY STAR for Homes guidelines and adopted them to their climate, and then incorporated other non-energy elements, such as water and resource efficiency (NAHB Research Center, 2002). In addition, some builders and remodelers have taken significant strides towards energy-efficient building, both with and without the assistance of a green building program.

The most influential non-governmental organization in advancing energy-efficient buildings is the U.S. Green Building Council (USGBC). The USGBC administers the Leadership in Energy and Environmental Design (LEED) rating systems which give a third-party certification for the level of achievement among five separate credit categories: Sustainable Sites, Water Efficiency, Energy and Atmosphere, Materials and Resources, and Indoor Environmental Quality. The USGBC initially certified only new commercial construction, but has expanded to cover existing building operations and maintenance, commercial interior projects, commercial core and shell projects, neighborhood developments which will be released for pilot in early 2007, and most recently a pilot program for homes. Founded in 1993, the USGBC now has over 6,300 member companies and organizations representing over 90,000 active individuals, and has certified 550 projects. The program has grown at over 20% a year since 2002, and there currently are 4,500 registered projects in the pipeline representing 550 million square feet. (Pusey, 2006).

To be LEED certified, a building must meet certain prerequisites and then choose credits to pursue to get to the minimum number of points. There are four levels of certification, based on the number of points earned: certified, silver, gold and platinum.

Building a LEED certified building costs more up front than a building that doesn't meet LEED standards. Although the following example is for commercial buildings, incremental costs for housing should be roughly equivalent. Incremental costs for building a new LEED commercial building (LEED-NC) is minimal based on

50 LEED-NC projects. The hard costs of doing LEED are 0.7% for LEED certified, 1.9% for LEED silver, 2.2% for LEED gold, and 6.8% for LEED platinum. However, as markets become more familiar with LEED, costs decrease substantially because of smaller learning curves and increased competition (Oliver, 2006). We can expect that these trends will prove to be similar for LEED for homes.

LEED is often cited as the best green building rating system because it is developed using a consensus based process. Each system is developed by an elected committee, and before going live there is a public comment period and pilot projects test each new rating program. Because LEED is the only national green building certification program (ENERGY STAR for homes is national, but it only incorporates energy, not the other aspects of green building) it allows large production builders who build throughout the country to use one rating system, rather than unique systems for each state. This will prove to be a bigger issue as the homebuilding industry continues to consolidate (Lefaix-Durand et al., 2005).

A smaller, regional green building program is EarthCraft House. It is one of more than 40 local and regional green building programs throughout the United States. A partnership between the Southface Energy Institute and the Greater Atlanta Home Builders Association, EarthCraft started certifying new homes in 2000. In that first year, it certified only eight homes. As of 2005, over 2,500 homes have been certified. Like the LEED rating system, each builder must take a class before being allowed to build certified homes.

EarthCraft awards points towards certification in 11 areas: Site planning; energy-efficient building envelope and systems; energy-efficient lighting/appliance; resource efficient design; resource efficient building materials; waste management; indoor air quality; water-indoor; water-outdoors; home buyer education; and, builder operations. Builders must earn the necessary 150 points in any manner of their liking, except that they must earn between 75 and 85 points in the building envelope section. This flexibility allows builders to find the most cost-effective and marketable measures to meet the EarthCraft standards for their buildings.

EarthCraft is unique in the country because it is the only program to diagnostically test every home for compliance. The only exception is for production builders, whose homes are randomly sampled. EarthCraft has had so much success in the Atlanta market that it is now expanding to the rest of Georgia, Florida, Tennessee, Alabama, South Carolina, and Virginia (EarthCraft House, 2004).

Another influential green building program includes the Austin, Texas Green Building Program, which was the first in the country. Since its start in 1990, this utility sponsored program has branched out from new single-family construction to commercial and multifamily housing, certifying more than 2,500 homes (Austin Energy, 2006).

EXAMPLES OF ENERGY-EFFICIENT HOMES:

America knows how to make housing more efficient. Be it the construction of single-family or multifamily homes, or making existing housing more efficient, the resources and technical expertise is available. However, many builders aren't aware of the resources, or don't realize how easy they are to use.

For many single-family builders who have taken the first steps and learned how to build energy-efficient homes, they haven't yet learned how to market these upgrades. They have found that it is easier to sell high-end cabinets, which buyers can see, than it is to sell improved insulation and air sealing, which is hidden behind the walls.

Even more resource and energy-efficient than single-family homes are multifamily homes. Multifamily homes use only 38% of the energy as single-family homes (Energy Information Administration, 2004). There have also been fewer challenges to building and selling energy-efficient multifamily homes, due in part to large financial incentives from local utilities. However, there is far less demand for multifamily homes than for single-family homes.

However, the bulk of energy-saving potential is in making existing homes more energy-efficient. The most effective ways are by insulating and air sealing them, and updating aging appliances and mechanical equipment with new, energy efficient models. The potential for huge monetary and energy savings exists through these measures because even during the housing boom of the last few years, the number of housing units nationwide increased by only 1 or 2% each year (US DOE, 2005). However, the same lack of public awareness and demand for energy-efficiency that exists for new construction is prevalent in weatherization.

The following examples demonstrate builder's ability to build an energy-efficient home, but with varying economic success.

Single-Family Homes:

Faced with increasing shortages of skilled labor, and the desire to create a market niche through high-performance homes, Pulte Homes made a long-term business decision to invest in innovation. The decision was based on years of internal research and a corporate mission to embrace innovative solutions (PATH, 2006).

The 2nd largest homebuilder in America, Pulte invested significantly in manufacturing capacity to supply its new division, Pulte Home Sciences. From its panel factory, Pulte manufactures concrete foundations, open-web floor joists, structural insulated panel (SIP) external walls, and steel-framed interior walls to create energy-efficient, durable homes.

Pulte manufactures and supplies factory-built panels similar to those that are available from other manufacturers, but Pulte standardized the products by designing and building its own. Pulte is the first large stick-building company to invest in their own panel manufacturing plant. This, and the quality of the products that they produce, put them at the forefront of single-family homebuilding industry. The only other builders in the nation that deliver a home of similar quality are small-production or custom builders, and there aren't many of them.

"The design and selection of the individual subsystems of our homes were carefully chosen to support our dedication to whole house performance," says Chuck Chippero, General Manager of Pulte Home Sciences. "We developed individual subsystems that complemented each other from a structural, thermal, moisture management, and—very importantly—an assembly standpoint. Our goal was to reduce the ultimate operating cost to the homeowner by providing them with a high-efficiency home" (Chippero, 2006).

Pulte's foundation uses a very high-yield strength concrete. They use a 5,000+ psi concrete (rather than the industry average of 3,000 psi) for on-site curing. The high density in the concrete makes the foundation more water resilient, which is a benefit to the homeowner. After shipping and installing the concrete panels, site workers apply a moisture curing urethane at the seams of the foundation which further protects the foundation from moisture.

Once the foundation walls are installed, a pre-fabricated open-web floor truss is laid. Because they use a pre-fabricated flooring system, they can install it in only a few hours (rather than days). For small to medium sized houses, Pulte can install the foundation, the floor system, and backfill in a 10-hour day.

Next, Pulte installs SIP exterior walls. SIP's are used because they provide more consistent wall insulation, which is more energy-efficient than stick-built walls. SIP walls are also much stronger than stick built walls.

Pulte uses steel walls for the interior, chosen because they are lighter and straighter than wood framed walls. They use a G-60 coating on the steel to prevent rust, which increases the longevity of the steel.

It takes Pulte 19 days on average from the day they lay the foundation, to when they hand the home over to the mechanical contractor. The speed minimizes weather-related problems. Scheduling is more consistent, and the building materials do not get wet, which can compromise their quality.

Installation costs are much lower because a smaller, less-skilled crew assembles the house more quickly. Instead of using a crew of carpenters, they use a crew of less costly installers, with a single carpenter to manage the crew (PATH, 2006).

"Our customers tell us that they are seeing substantial energy savings per month," Runnels says, of up to and sometimes more than $100 a month. "Some of our homeowners have compared utility bills with friends and neighbors who live in similar size and style conventional houses and are very satisfied with the savings they are realizing" (Runnels, 2006).

Consumer acceptance of the PHS technology house has been very positive. However, the biggest hurdle is to understand how potential homeowners value the numerous performance benefits. Simply stated, what price premium would a potential customer be willing to pay?

"Educating the market about what you are providing becomes a key factor to accepting what we are trying to do: providing a superior house," says Runnels (PATH, 2006).

This is also the challenge Pulte Home Sciences is facing.

"Most homeowners don't perceive the value of a high quality, high-durability, energy-efficient home," Runnels says. "We have only just begun to look at trying to market this package as a premium house…and it truly is a premium product. It's all about education. For a given price, how do we get the customer to choose a much better, higher performing house that utilizes premium materials and technology over a conventional house with upgraded cabinets and counter tops? We haven't figured it all out yet, but we're working on it" (PATH, 2006).

Pulte's experience demonstrates that the technology to build high-performance, energy-efficient homes is known and available. However, because the marketplace is not able to distinguish – and therefore demand – a high-performance home, Pulte is not able to earn back their investment, and may soon close the doors on the PHS manufacturing plant.

The irony is that many energy-efficient homes, although slightly more expensive to purchase, actually costs less to own. Most buyers decide how much home they can afford by looking only at their monthly mortgage costs. Although this is the greatest expense, it's not the only one. They should also include monthly insurance, utility, and maintenance bills to get a true picture of home ownerships costs.

For many homes, for a typical 2,500 square foot home in Orlando, it costs only $5,813 to get a number of energy-efficient upgrades such as efficient windows, increased insulation levels, ENERGY STAR appliances, high-efficiency heating and cooling equipment, thorough air sealing and a tankless water heater (See Table 5). These upgrades would lower the monthly energy bill by $49.75. If the additional $5,813 gets rolled into the 30-year mortgage at 6%, it would increase the monthly mortgage by $36.74. The net result is $12 savings per month, and these savings would only increase as energy prices rise above the $.089 per kWh assumed (PATH, 2005). And there are of course other benefits that can't so easily be accounted for in a simple analogy like this: increased comfort, insulated storage space in the attic, better indoor air quality, and lower carbon dioxide emissions.

	Conventional Construction	Construction with Key PATH Upgrades*
Base Price	$ 225,000	$ 230,813
Downpayment	50,000	50,000
Mortgage Total	175,000	180,813
MONTHLY PAYMENT		
30 Yr @ 6%	1,106.12	1,142.86
Homeowners Insurance	100.00	100.00
Utilities	152.25	102.50
Total Monthly Costs	$ 1,357.37	$ 1,345.36

*Key Home Upgrades; Home Built to Orlando, Florida Codes

Home built to 2000 IECC Specs	PATH Home Specs	Estimated Costs for Upgrade
13 SEER heat pump	15 SEER heat pump	$1,500
Conventional water heater	Tankless water heater	$385
Code double-paned windows	ENERGY STAR® qualified windows	$250
R-19 fiberglass ceiling insulation	R-19.8 sprayed foam ceiling insulation	$1,586
R-11 fiberglass wall insulation	R-14.4 sprayed foam wall insulation	$757
R-11 fiberglass floor insulation	R-18 sprayed foam floor insulation	$1,261
Refrigerator/clothes washer	ENERGY STAR qualified refrigerator/clothes washer	$74

Table 5: Monthly cost savings from owning an energy-efficient home (PATH, 2005).

Multifamily High-Rise:

Multi-family high-rises are typically the most energy-efficient of all housing options. The average single family home used 107.3 x 10^6 Btu in 2001, while multifamily units in buildings with at least 5 units used 41.0 x 10^6 Btu (Energy Information Administration, 2004). They use less energy than single-family homes because they are usually smaller, and they don't have as many walls or ceilings exposed to the outdoors (which is where energy loss occurs). Not only do multi-family buildings have a lower energy intensity, but they are typically closer to masstransit and other local amenities than single family homes, decreasing resident's dependence on personal automobiles.

However, multifamily housing, in particular high rises, must fight against the American dream of owning your own home with a white-picket fence. But with the increasing cost of transportation, and the lowering of crime rates in the city, young professionals and retires are heading back to downtown in record numbers to live in luxury multifamily buildings.

One such building that is benefiting from this transition is the Meriwether, a multi-family high-rise on the banks of the Willamette River just South of downtown Portland, Oregon. What makes the Meriwether unique is that it incorporates many green, energy-saving features. This makes living in it even more environmentally beneficial than a conventional suburban single-family home (Ferington, 2006).

The Meriwether consists of two towers. The East tower is 21 stories; the West 24 stories. There are also town homes and retail space on the ground floor. Of the 610,000 square feet, 460,000 are for residential, 10,000 for retail, and 140,000 for parking. 203 of the 245 units are condos, 17 are town homes, and 25 penthouse condos. Prices range from $249,000 to $1.9 million for the 638 to 3,123 square foot units (Riegel, 2004).

The design process was very typical for green buildings. First, the building envelope was designed to be efficient. The building was orientated to minimize solar heat gain, and high performance glazing with a U-value of 0.31 was installed. Insulated concrete panels were then designated for the rest of the façade. These panels have an R-value of 19, greater than the R-15 required by code. An eco roof with rainwater collection for irrigation was also designed (Ferington, 2006).

Next, highly efficient mechanical equipment was specified. Chilled water created at a centralized plant that serves the entire district provides the cooling via indirect evaporative cooling. Natural ventilation and shading by the patios minimizes the need for artificial cooling. Each unit has their own highly efficient 96 AFUE gas-fired furnaces for heating. Hot water is supplied from a central boiler plant within the building that could be supplemented with heat from solar hot water collectors.

Other green features include prioritizing material manufactured within 500 miles of the project to minimize the energy used in transport. The developers also specified materials with recycled content, and Forest Stewardship Council (FSC) certified wood.

Dennis Wilde, senior project manager with Gerding/Edlen for the Meriwether stated, “As developers, our primary motivation is doing the right thing. We have to start finding ways to build and operate our buildings in a more respective way to the natural environment” (Riegel, 2004).

Construction began in April 2004, and was completed in May 2006. A common observation of people not familiar with green buildings is: ‘I couldn’t tell it was green by looking at it. It looks just like other buildings!’ Many architects and green building owners argue that they look better because they allow for the adequate use of daylighting, and they often bridge the gap between the interior and the outdoors. The Meriweather is no different. It’s mostly glass façade (44% window to wall area) and numerous balconies are not only visually appealing, but have proven to be good selling points. The building is now over 94% sold.

The building should achieve a LEED Gold standard once all the paperwork is complete, due in part because it expects 19% savings in electricity demand and 7% savings in natural gas use from the stringent 2003 Oregon Energy Code. The primary savings come from very efficient lighting. It uses only 0.17 W/sf for high intensity discharge lighting in the non-residential space; 0.9 W/sf compact fluorescent lighting & MR16 fixtures in residential space; 0.3 W/sf in the garage; and 1.9 W/sf in the retail space. The lighting schedule uses only 750 full load lighting hours. Annual energy cost savings of $28,500 allow a 3.9 yr. payback from the additional $110,000 it cost to install all of the energy-efficient lighting. The developers, Gerding/Edlen Development and Williams & Dame Development also received $44,518 of the total $97,308 in incentives for their lighting upgrades (Ferington, 2006).

Like many other developers of large, energy-efficient multifamily buildings, the Meriweather’s developers worked with the local municipality and utility provider in order to receive financial incentives for their efficiency upgrades. They received their incentives from the Energy Trust of Oregon’s building efficiency program for their energy efficient upgrades. The efficiency upgrades are estimated to result in 868,253 kWh of electricity saved per year, and 2,247 therms of natural gas (Ferington, 2006). This will prevent about 60,000 tons of CO_2 emissions annually.

Remodeling for Energy Efficiency:

It's not possible for everyone to pick up and move into an energy-efficient condo downtown, even if it is the most environmentally friendly way to live. But every homeowner can do what he or she can to make their current homes more energy efficient. Realistically, making existing homes a little more energy efficient will have a greater impact on lowering carbon dioxide emissions than making all new homes extremely energy-efficient. The reason is that there are over 100 million homes in America, while roughly 1.5 million new homes are built every year (U.S. Department of Commerce, 2006).

Making a home more energy-efficient isn't very difficult, if you know what to do. The most important step is to locate and seal up air leaks. This can only be properly done by performing a blower door test. Without the blower door, one can only speculate where air leaks are.

Michael Lotesto, President of Performance Exteriors LLC, does building performance testing and remodeling. By running diagnostic tests like the blower door, Lotesto is able to determine exactly where and why homes are leaking air.

Lotesto treats a home like a doctor treats a patient. He diagnoses the problem by examining symptoms, and then he determines exactly what the cause is.

"First, we do a visual inspection and heat loss calculations of the siding, foundation, roof, ceilings, walls, windows, and doors to find out what areas needed the most attention," says Lotesto. "Then we do a blower door test. The blower door test runs a negative pressure in the home that emphasizes any points of air infiltration in the house. We section off individual rooms and crawl spaces, then use a second manometer to take pressure readings to determine specifically where the house was leaking the most air. A house that is properly air sealed will replenish far less than half of its air in the space of an hour. Many older homes let in outside air at double or three times this rate. In addition to lowering utility bills, air sealing also makes the air in the home cleaner and healthier because air is the number one carrier of moisture and bacteria" (Fried, 2006).

The cost of the testing is about $400, although many utilities offer deep discounts. Although the cost to air seal and insulate varies from a few hundred to many thousand dollars, on average the upgrades cost a few thousand. For a typical 1960's brick home that Lotesto tested in Illinois, he did about $2,500 dollars worth of efficiency upgrades which he estimates will save the homeowner $700 a year on the energy bill.

Other easy ways to make homes more energy efficient include using fluorescent lighting, purchasing ENERGY STAR qualified appliances, windows and mechanical equipment, and even planting trees to shade the home in the summer. Installing photovoltaic cells to generate electricity is also another valuable upgrade, and it has become economical due to federal and local tax incentives and high electricity costs.

But air sealing and adding additional insulation to the attic is the best way to lower most homes' energy use. But there is little funding dedicated to promoting programs to educate homeowners and remodelers about building performance testing, and outside of California, no state and only a few local agencies require energy rating.

"Public awareness is the greatest challenge facing us right now," says Lotesto (Fried, 2006).

FUTURE OF ENERGY-EFFICIENT BUILDING:

Although the technical resources are available to make buildings far more energy efficient than they are currently being built, most builders are not building energy-efficient homes. Although they are partially to blame, one of the main reasons that builders are not building energy-efficient homes is because of the lack of customer demand. Without demand for an efficient product, builders have little motivation or incentive to change their building practices.

The main reason that consumer demand doesn't exist is that most Americans don't think about home energy-efficiency. But as more Americans become concerned about energy in general, they are more likely to become more interested in energy-efficiency.

The time is ripe for energy efficiency, and the following factors give rise to optimism:

- Rising energy costs. Increased world demand is causing the run up in oil, electricity, and natural gas prices (Energy Information Administration, 2005). Because this is different from the supply disruptions of the past, there is a growing consensus that high prices will only continue to increase. In addition, current projections show U.S. energy demand increasing by more than one-third by 2030, with electricity demand alone rising by more than 40 percent (Energy Information Administration, 2005).

- National energy security. The disruption to the U.S.'s energy supply by hurricane Katrina increased the awareness of energy as a national security issue. Combined with growing displeasure over the war in Iraq, which many argue was at least partially fought over oil, most Americans want energy independence. The federal government realizes this as well. The Partnership for Home Energy Efficiency states, "because buildings are significant consumers of natural gas and electric power, conservation in this sector is now becoming an energy security issue, as well as an environmental and economic issue." (D&R International, 2006).
- The pending need for substantial energy infrastructure investments. Growing energy demand is stressing existing systems for power generation, power transmission and distribution, and natural gas transmission and distribution. These capacity constraints can potentially compromise energy system reliability and contribute to higher energy prices in or near congested areas. Massive blackouts in the U.S. in 2004 brought this issue to light. This has caused many electric utilities to focus on ways to reduce load, such as home energy efficiency, which they have deemed to be more economical than increasing supply.
- The growing awareness of building technologies as a key to disaster mitigation and recovery. An analysis by ICF Consulting found that a $900 million investment in energy efficiency for rebuilding the 310,353 destroyed homes of Hurricane Katrina to ENERGY STAR standards would pay for itself in just 7.5 years (Polluck, 2006). In addition, Katrina and the other hurricanes of 2005 were a wakeup call to many Americans that climate change has a real and direct impact on their lives.
- Residential tax credits from the 2005 Energy Policy Act. Builders and homeowners have an added financial incentive through December 2007 to improve the energy-efficiency of their homes.
- Rapid growth of the green building movement. 2005 saw a 20 percent increase in the number of home builders producing green, environmentally responsible homes. That number is expected to grow by another 30 percent in 2006

(McGraw-Hill Construction, 2006). In just 10 years, ENERGY STAR has gone from certifying 55 homes in 1995 that met its standards to 130,000 in 2004 (ENERGY STAR, 2006). Every business day, 25 new professional become LEED accredited professionals (LEED-AP), 10 new projects equivalent to $200 million in construction starts to register, 1 project is certified, and 50 LEED-based educational trainings are held (Pusey, 2006).

- Slowing housing market. Sales of new single-family homes fell 3% in June to a seasonally adjusted annual rate of 1.131 million units, following a downward revision to the sales rate for May (U.S. Department of Commerce, 2006). In addition, actual new home sales for the first half of the 2006 were down 11.9% from the same period of a record-setting 2005. As a result, builder confidence is down significantly. The Housing Market Index of builder confidence plummeted from 72 in June 2005 to 39 in July 2006 (National Association of Home Builders, 2006). This may drive builders to better differentiate themselves in the slowing market where buyers are becoming more concerned over energy prices (National Association of Home Builders, 2006).
- Commitment to the Action Plan for Energy Efficiency. In July, 2006, 72 leading organizations in 33 states signed an agreement which aims to help states and utilities implement successful long-term investments in energy efficiency. The plan builds upon best practices from successful energy efficiency programs, including many programs that can spur consumer demand of home energy-efficiency. (Environmental Protection Agency, 2006).

CONCLUSION:

Cheap energy has been a key factor in the U.S.'s strong industrial and economic development. However, there has been an ugly downside to cheap energy: American society uses it very inefficiently. As a result, the U.S. emits 23.8% of the world's carbon dioxide emissions (Energy Information Administration, 2006). It is in the country's best interest to lower energy use, via tax credits, federal programs, energy codes, and by encouraging civil society to engage the population to begin considering energy use in their purchases and daily habits.

The most economical way to significantly lower national energy use is to make housing more energy efficient because the technological capabilities exist. It is also more feasible than energy conservation because it doesn't require a fundamental change in consumer behavior. However, it does require that builders must change some of their building methods, and homeowners must demand more efficient homes since builders will not change their practices unless the market forces them to do so.

The impact of improving the energy efficiency of America's homes is significant. If the 110 million existing homes could be made 20% more efficient – already shown to be a realistic goal achieved through weatherization strategies and purchasing ENERGY STAR qualified products – the U.S. economy would save 37 billion dollars by using 4.2 percent less energy, lowering worldwide greenhouse gas emissions by 1% or 250 million tons. If all new homes get built to be 30% more efficient over the next 10 years, an additional 200 million tons of CO_2 pollution would be prevented (Assuming 1.13 million new units/year: National Association of Home Builders, 2006; Energy Information Administration, 2006). This would be a major step for the U.S. to decrease the amount of climate change causing greenhouse gases polluted into the atmosphere. If building practices are left unchanged, inefficient homes will continue to cause dire consequences to the world because of their contribution to global climate change.

WORKS CITED:

Adler, J. 2006. Green America: Why Environmentalism is Hot. Newsweek. July 17, 2006. http://www.msnbc.msn.com/id/13768213/site/newsweek/

Advanced Energy. 2006. The Business Case for Energy Efficiency. White Paper. August, 2006.

American Demographics. 2001. Earth in the Balance - American's attitudes towards the environment. October 20, 2006. http://www.findarticles.com/p/articles/mi_m4021/is_ISSN_0163-4089/ai_75171057

Arieff, A. 2006a. Green Goes Mainstream: Sex and Sustainability. Dwell. September 2006. Page 39.

Arieff, A. 2006b. Green is Good: Let's Make Green the New Black. Dwell. December/January 2006. Page 41.

Associated Press. 2006. Gas prices have mixed impact on automakers. May 2, 2006

Austin Energy. 2006. Austin Energy Green Building Program. http://www.austinenergy.com/Energy%20Efficiency/Programs/Green%20Building/index.htm (6/8/2006)

Beck, E. 2006. Earth-Friendly Materials Go Mainstream. New York Times, January 5, 2006. http://www.nytimes.com/2006/01/05/garden/05green.html?ei=5090&en=ffd4cbd3b74dc287&ex=1294117200&partner=rssuserland&emc=rss&pagewanted=print (5/1/2006)

Benn, H. 2006. Eliminating World Poverty: Making Governance Work for the Poor. A White Paper on International Development. July 2006

Birkeland, J. 2004. The Centrality of Design. In Design for Sustainability: A Sourcebook of Integrated Eco-logical Solutions. Edited by Dr. Janis Birkeland. London: Earthscan.

Buck, M. and Verheyen, R. 2001. International Trade Law and Climate Change –A Positive Way Forward. July 2001. FES-Analyse Ökologische Marktwirtschaft. Hamburg: University of Hamburg

Building Codes Assistance Project. 2006. August 8th, 2006. http://www.bcap-energy.org/code_status.php.

Chipero, C. 2006. Pulte Homes Sciences. Personal Interview, July 12, 2006.

Christie, L. 2006. Green Goes Mainstream: High Energy Prices Can Make an Environmentalist Out of Any Homeowner. CnnMoney.com. April 17, 2006. http://money.cnn.com/2006/04/14/real_estate/green_in_mainstream/index.htm

Consortium for Energy Efficiency. 2005. Consortium for Energy Efficiency Household Surveys. Washington, DC. 2005.

Corbett, J. 2005. Altruism, Self-Interest, and the Reasonable Person Model of Environmentally Responsible Behavior. Science Communication, Vol. 26, No. 4, 368-389.

D&R International. 2006. PHEE Annual Report for 2006. Unpublished. August, 2006.

Desanker, P. 2002. Impact of Climate Change on Life in Africa. Center for African Development Solutions. Johannesburg, South Africa http://www.geog.psu.edu/geclab/miombo/Publications/WWF_Brief/africa_climate.pdf;

Dooley, R. and Rivera, J. 2004. Green Building Goes Mainstream. Professional Builder. March 1, 2004. http://www.housingzone.com/article/CA467110.html (5/5/2006)

EarthCraft House. 2004. EarthCraft House Credit Guidelines.

Energy Information Association. 2004. A Look at Residential Energy Consumption in 2001. April 2004.

Energy Information Administration. 2006. Annual Energy Outlook 2006. Washington, DC.

Energy Information Association. 2005. Annual Energy Outlook 2005. Washington, DC. 2005.

ENERGY STAR. 2006. www.energystar.gov (1/2/2006).

Environmental Protection Agency. 2006. National Action Plan for Energy Efficiency Leadership Commitments. http://www.epa.gov/cleanenergy/actionplan/leadership.htm (5/8/2006)

Fedrizzi, R. 2004. Buildings.com Greener Facilities Newsletter. November 2004. http://www.buildings.com/Articles/detail.asp?articleID=2215

Ferington, D. 2006. High Rise ENERGY STAR Multifamily National Pilot Panel. Multifamily Buildings 2006, New York. June 26, 2006.

Fields, S. Continental Divide: Why Africa's Climate Change Burden Is Greater. Environmental Health Perspectives. Volume 113, Number 8, August 2005. http://www.ehponline.org/docs/2005/113-8/toc.html

Fortune Magazine. 2006. Building a Greener Future. Fortune Magazine. March 20, 2006. http://www.nxtbook.com/nxtbooks/rms/fortune-greenbuildings/index.php (20/3/2006)

Foss, A. 2006. Going Green Step by Step. California Builder Magazine. January/February 2006.

Fried, K. 2006. Interview with Michael Lotesto. April 23, 2006.

Green Building Pages. 2004. http://www.greenbuildingpages.com/sustainability/intro.html. (13/7/2004).

Hargreaves, S. 2006. Gas prices won't slow holiday driving. CNNMoney.com. May 18, 2006.

Koebel, C., M. Papadakis, E Hudson, and M. Cavell. 2003. The Diffusion of Innovation in the Residential Building Industry. Prepared for U.S. Dept. of Housing and Urban Development.

Lefaix-Durand, A., Robichaud, F., Beauregard, R., Kozak, R., Rayret, J., and Poulin, D. 2005. Procurement Strategies in the Homebuilding Industry: An Exploratory Study on the Largest Builders in the United States. December 2005. Working Paper DT-2005-DP-2. Network Organization Technology Research Center. University of Laval. http://www.forac.ulaval.ca/Centor/Documents/Documents%20de%20travail%202005/DT-2005-DP-2.pdf

Lippke, B., Wilson J., Perez-Garcia, J., Bowyer, J., and Meil, J. 2004. Life-Cycle Environmental Performance of Renewable Building Materials. Journal of Forest Products. June, 2004.

Lockwood, C. 2006. Building the Green Way. Harvard Business Review. July/August 2006. http://harvardbusinessonline.hbsp.harvard.edu/hbrsa/en/hbrsaLogin.jhtml;jsessionid=YD2NCIIR3D0PQAKRGWDSELQBKE0YIISW;$urlparam$kNRXE2ULYRiR52NiwJYH5SF?ID=R0606J&path=&pubDate=null&referral=null&_requestid=43019 (1/8/2006)

McGraw-Hill Construction. 2006. Innovative Products & Practices in Residential New Construction. June 2006. http://www.pathnet.org/si.asp?id=2681

McGraw-Hill Construction. 2006. McGraw-Hill Construction/National Association of Home Builders (NAHB) Survey. http://www.nahb.org/news_details.aspx?newsID=2727&print=false (9/7/2006)

National Association of Home Builders. 2006. Green Building Barrels into the Mainstream Market. Nation's Building News. March 20, 2006. http://www.nbnnews.com/NBN/issues/2006-03-20/Front+Page/index.html

National Association of Home Builders. 2006. The NAHB/Wells Fargo Housing Market Index (2003-Present). http://www.nahb.org/generic.aspx?sectionID=134&genericContentID=529 (4/8/2006)

National Association of Home Builders. 2006. Uncertainty Over Fed Helps Sink Builder Confidence. Nation's Building News. July 24, 2006 http://www.nbnnews.com/NBN/issues/2006-07-24/Economics+%26+Finance/2.html

NAHB Research Center. 2002. Summary of Existing Green Building Programs. Second Edition. July 2002. http://www.nahbrc.org/Docs/MainNav/GreenBuilding/3643_Summarycomplete.pdf?TrackID=&CategoryID=1801&DocumentID=3643

Oliver, E. 2006. Evaluating the Costs of Green/High Performance Buildings. Multifamily Buildings 2006. New York. June 27, 2006.

Partnership for Advancing Technology in Housing (PATH). 2005. Written by Asa Foss. http://www.pathnet.org/sp.asp?id=17710

Partnership for Advancing Technology in Housing (PATH). 2006. Written by Asa Foss. http://www.pathnet.org (4/5/2006)

Polluck, E. 2006. Moving Energy Efficiency and Renewables into the Mainstream. Multifamily Buildings 2006. New York. June 26, 2006.

Pusey, A. 2006. U.S. Green Building Council. Personal Interview, August 4, 2006.

Residential Energy Services Network. 2006. http://www.natresnet.org/ (6/6/2006).

Riegel, R. 2004. South Waterfront Development to Include Green Initiatives. The Daily Journal of Commerce. Wednesday, June 30, 2004.

Roberts, P. 2005. The End Of Oil: On the Edge of a Perilous New World. New York: Mariner Books.

Runnels, S. 2006. Pulte Homes Sciences. Personal Interview, July 12, 2006.

Scott, D and Willits, F. 1994. Environmental Attitudes and Behavior: A Pennsylvania Survey. Environment and Behavior, Vol. 26, No. 2, 239-260.

U.S. Department of Commerce. 1999. U.S. Census Bureau. July 27, 2006 http://www.census.gov

U.S. Department of Commerce. 2005. U.S. Census Bureau. July 27, 2006 http://www.census.gov

U.S. Department of Commerce. 2006. U.S. Census Bureau News Joint Release for U.S. Department of Housing and Urban Development. July 27, 2006 http://www.census.gov/const/newressales.pdf

U.S. Department of Energy. 2005. Buildings Energy Data Book. Washington, DC. http://buildingsdatabook.eren.doe.gov/

University of York. 2005. Scientists warn of dramatic impact of climate change on Africa. Space and Earth. June 09, 2005. http://www.physorg.com/news4465.html

Valverde, Jr., L. and Andrews, M. 2006. Global Climate Change and Extreme Weather: An Exploration of Scientific Uncertainty and the Economics of Insurance. Insurance Information Institute. New York. http://server.iii.org/yy_obj_data/binary/758416_1_0/I.I.I.%20Climate%20Study.pdf

Vanity Fair. 2006. Green Issue. Vanity Fair. April 11, 2006. http://www.vanityfair.com

Vogel, L., Colgrove, M., Neill, S., and Karpman, M. 2006. ENERGY STAR Multifamily Pilot Project: A Report from New York. Multifamily Buildings 2006. New York. June 26, 2006.